Bay Oil Production In Puerto Rico

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MAYAGUEZ, PUERTO RICO

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Cover Illustration.—One of the larger Puerto Rican bay plantations near the town of Adjuntas at an altitude of 1,000 to 1,500 feet.

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[1] In cooperation with the Government of Puerto Rico.

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BAY OIL PRODUCTION IN PUERTO RICO

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INTRODUCTION

There is considerable acreage of steep and rolling land in Puerto Rico that is for the most part either lying idle or yielding little or no profit. The bay-rum tree, *Pimenta racemosa* (Mill.) J. W. Moore, is a crop which can be grown successfully on much of this type of land. Several groves and scattered clumps of bay-rum trees are already well established in Puerto Rico with a total area approaching 1,000 acres. These groves are located in the central and southern portion of the island, mainly in the southeast section near Guayama (fig. 1).

The widely used bay-rum lotion, found on drug counters and in barber shops, consists of about 1 percent bay oil in a solvent of ethyl alcohol. Bay oil is distilled from leaves of the bay-rum tree and is the active ingredient in the lotion, giving it the characteristic odor. Bay rum is soothing to the skin and is considered to have some healing qualities which are attributed to the antiseptic action of the phenols

[1] In the preparation of this circular the authors appreciate the advice given by bay growers and distillers, namely, Juan Mayoral of Ponce, Arturo and José Figaredo of Guayama, and Mr. and Mrs. Salvador Vives Bazan of Adjuntas. Luis A. Izquierdo, Commissioner of Agriculture of the Government of Puerto Rico, San Juan, and several departments of agriculture in the West Indies supplied statistical production and shipping data. J. Barnard Gibbs and Hugh W. Taylor of the Office of Foreign Agricultural Relations, Washington, D. C., supplied additional export-import data. The authors also appreciate the advice and consultation of Merriam A. Jones and Noemi Arrillaga, former co-workers on the essential oils project at the Federal Experiment Station.

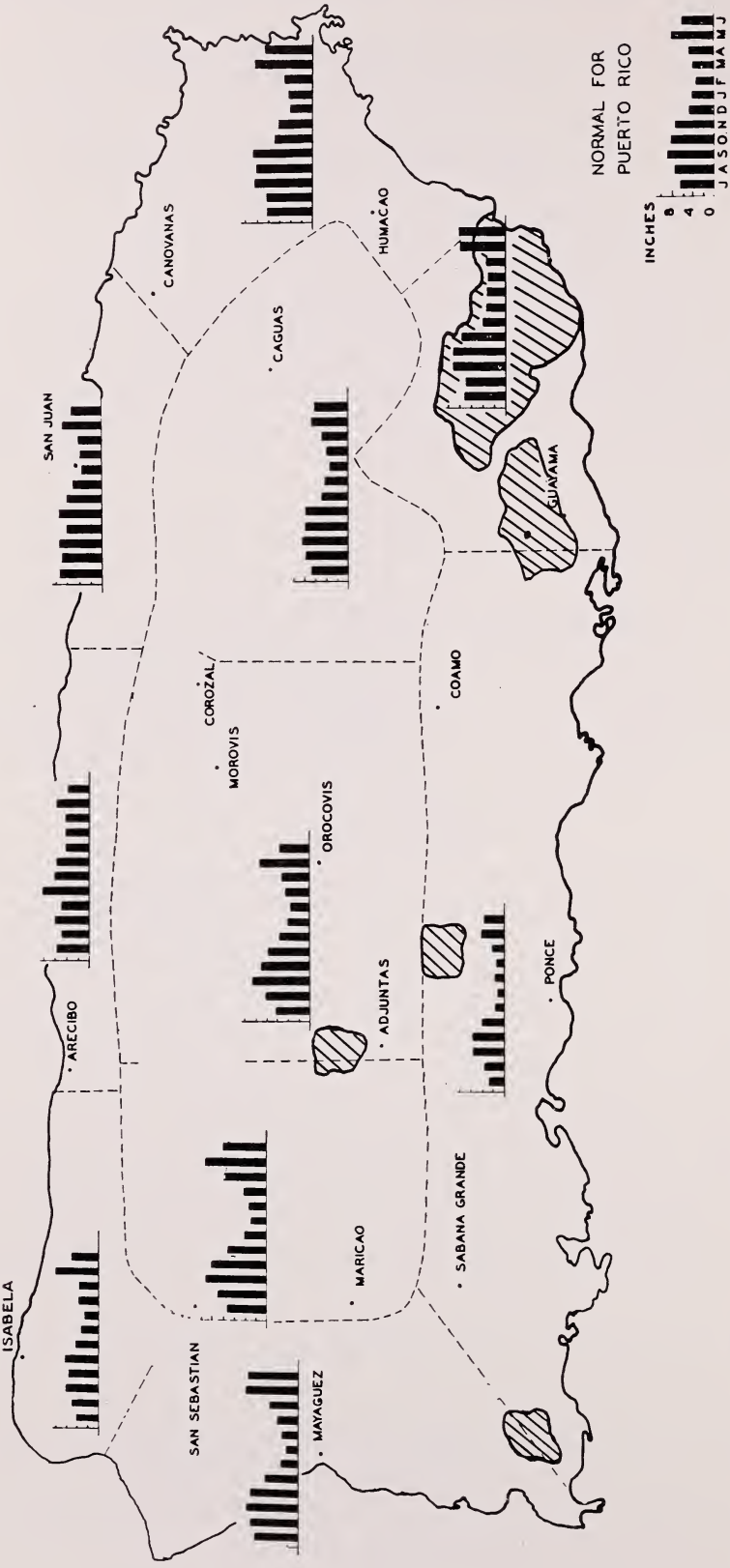

FIGURE 1.—Approximate location of bay-rum tree plantings in Puerto Rico are indicated by cross-hatched areas. The industry is largely centered in the southeastern corner of the island where 35,000 to 50,000 pounds of bay oil are distilled annually. A number of trees are located in the drier southwest corner near Cabo Rojo. (Bar graphs indicate average monthly rainfall by district.)

in the oil. Wood of the bay-rum tree is sometimes used in furniture manufacture; it also makes good charcoal, but the removal of bay-rum trees for this purpose is discouraged.

PRODUCTION AND MARKET SITUATION

Practically the entire world's supply of bay oil comes from the West Indies. The United States Virgin Islands, principally St. John, lead in production of bay oil, but in recent years their production has been almost nil: Puerto Rico and Dominica have about equal productive capacity, although bay-oil and bay-rum exports from all of the islands may vary considerably from one year to the next (table 1). Montserrat of the British West Indies conducted a research and promotion program for bay-rum trees in the early 1900's, but Montserrat has never been a large producer.

Oil produced on some of the West Indian islands is exported to neighboring islands for processing into bay rum. Jamaica (see table 2) and Puerto Rico, for example, may receive oil from the United States Virgin Islands or other islands for processing with local alcohol and for use locally or for exportation to the United States and Europe. The United States is the largest consumer of bay oil; large quantities

TABLE 1.—*Bay-oil and bay-rum exports from leading islands of the West Indes*

Year	Puerto Rico [1]		United States Virgin Islands	Dominica, British West Indies		Montserrat, British West Indies	
	Bay oil	Bay rum	Bay oil [2]	Bay oil	Bay rum	Bay oil	Bay rum
	Pounds	*Gallons*	*Pounds*	*Pounds*	*Gallons*	*Pounds*	*Gallons*
1930	13, 299	7, 437	12, 800	15, 948	-------	1, 564	-------
1931	16, 304	7, 897	15, 200	17, 783	-------	422	-------
1932	11, 136	4, 721	3, 200	20, 915	-------	886	-------
1933	16, 654	6, 043	-------	21, 774	76	722	-------
1934	15, 967	6, 289	-------	14, 988	549	434	-------
1935	11, 823	3, 089	34, 056	14, 988	516	-------	-------
1936	18, 484	3, 925	48, 068	21, 282	963	-------	-------
1937	22, 119	4, 769	51, 475	19, 635	714	272	-------
1938	13, 738	14, 006	54, 271	28, 666	1, 352	-------	-------
1939	10, 513	11, 931	30, 681	29, 624	698	-------	-------
1940	2, 366	-------	52, 718	24, 464	561	150	-------
1941 [3]	-------	-------	49, 522	50, 870	796	-------	29
1942	-------	-------	-------	24, 657	598	-------	-------
1943	-------	-------	-------	31, 232	411	44	-------
1944	-------	-------	-------	24, 275	287	-------	-------
1945	-------	-------	-------	31, 877	195	-------	-------
1946	-------	-------	-------	-------	-------	600	-------

[1] Export to United States only.

[2] Bay oil shipped as bay rum. Bay rum contains about 1 percent bay oil and weighs about 8 pounds per gallon. According to Oscar R. Bough, agricultural extension agent, Charlotte Amalie, St. Thomas, V. I., bay-rum production was almost extinct as of April 1947.

[3] Figures unavailable for bay oil and bay rum alone in Puerto Rico and the Virgin Islands during war period; they were included under "Perfumes, cosmetics, vegetable oils, bay rum, and toilet preparations."

of oil also are consumed in and near the production areas in the West Indies. In Puerto Rico, the export figures show only around 10,000 to 20,000 pounds of oil exported annually (table 1), whereas probably some 60,000 or more pounds are produced in some years (based on a survey of the distillers in 1946–47). Thus, over half the oil produced in Puerto Rico is used locally.

TABLE 2.—*Bay-oil imports and bay-rum production in Jamaica, B.W.I.*[1]

Year	Bay-oil imports		Bay-rum production
	Quantity in pounds	*Value*	*Gallons*
1940	216	78	457
1941			907
1942	2, 085	1, 350	1, 445
1943	918	798	1, 060
1944	3, 930	1, 827	813
1945	333	255	1, 058
1946	711	309	1, 248

[1] Largely from the United States Virgin Islands. Bay oil produced in Jamaica is negligible.

In the region of Guayama, it is estimated that about 3,500,000 pound of bay leaves are distilled annually, yielding between 1 and 2 percent bay oil, or, around 35,000 to 40,000 pounds of bay oil (fig. 1). Near Adjuntas there is a planting of about 120 acres. Above Ponce there is another planting of about 50 acres, whereas near Cabo Rojo the trees are mostly scattered with but few trees systematically planted. Trees in the latter region were not harvested for several years beginning shortly after 1940 owing to the death of a local distiller and to a temporary suspension of interest.

During periods of low general price level in the United States the amount of bay oil the market absorbs has been limited, but during periods of prosperity and high prices, as following World War II, the demand for bay oil far exceeded the supply in Puerto Rico. Thus, during slump economic conditions overproduction of bay oil, a more or less luxury item, may be experienced unless a definite sales program is initiated to increase consumption and to promote other uses of the oil, such as preparation of synthetic vanillin and use of the extracted eugenol in carnation perfumes.

BOTANY

The correct botanical name for the bay-rum tree is *Pimenta racemosa* (Mill.) J. W. Moore (*1, pp. 204, 483*). Botanical names which at one time or another have been assigned to the bay-rum tree are as follows (*5, p. 263; 6, p. 74*) :[2] *Amomis caryophyllata* (Jacq.) Krug & Urban, *Myrtus caryophyllata* Jacq., *Myrtus pimenta* Ortega, *Myrtus acris* Sw., *Myrcia acris* DC., *Pimenta acris* Kostel., *Pimenta acuminata* Bello.

[2] Italic numbers in parentheses refer to Literature Cited, p. 28.

Common names frequently used other than bay-rum tree are: Bayberry, wild cinnamon, "malagueta," "ausu," and "guayavita." Malagueta is commonly used in Puerto Rico.

Britton and Wilson (*12, p. 27*) give the following botanical description of the bay-rum tree (see also figs. 2 and 3):

A tree reaching a maximum height of about 15 m., with a trunk up to about 6 dm. in diameter, usually lower, mostly 5–10 m. high, sometimes shrubby, the angular and glandular twigs, the leaves and inflorescence glabrous or nearly so. Leaves elliptic, oblong-elliptic, or obovate, 5–15 cm. long, bright green and finely many-veined and reticulated on both sides, the apex rounded, obtuse, emarginate or sometimes acutish, the base narrowed or obtuse, the rather stout petioles 5–15 mm. long; panicles usually ample and many-flowered, longer than the leaves, glandular; calyx-teeth broad, short, acutish, petals rounded, about 4 mm. long; fruit oval to obovoid, 8–10 mm. long, few seeded.

Britton and Wilson (*12, p. 27*) state that the bay-rum tree grows on—

* * * hillsides and forests in moist districts, Puerto Rico, at lower and middle elevations; Vieques; St. Croix (according to Eggers); St. Jan; Tortola; Cuba; Hispaniola; St. Martin to Trinidad and northern South America. The leaves and twigs yield by distillation the important oil of bay or bay oil; a superior kind of this oil is produced on St. Jan where there are extensive forests of the tree, obtained for the most part by clearing away other trees and bushes thus permitting the bay trees to grow from seedlings without much cultivation. Much oil is also obtained from wild trees in Puerto Rico, but little or none in

FIGURE 2.—(*A*) Seed pods on a commercial bay tree in August, showing fruiting habit. (*B*) Flowering cluster of a bay tree in March. (*C*) Bay seed germinate best (left) when planted within 1 or 2 days after removal from the tree in August or September. Three petri dishes on the right show bay seeds planted 6 days after removal from the tree and drupes.

FIGURE 3.—(*A*) Properly trained bay tree near Guayama showing desirable growth and height (10 to 15 feet) for economical management. (*B*) Old bay tree near Adjuntas showing natural growth habit; circumference at breast height was about 7 feet. (*C*) A hillside of bay trees near Adjuntas showing a space at the left where trees have died; dead trees are also apparent throughout the planting. The grower attributed this to a root rot, probably aggravated by thin infertile soil conditions. (*D*) Vigorous bay trees near Guayama growing among boulders in moderately deep soil; such land is of little value for other crops.

St. Croix, St. Thomas, or Tortola. The species consists of many races differing mainly in the amount and quality of the oil contained, but also in shape, size and color of the leaves and shape of the fruit. The dark wood is strong, very hard, tough, mottled and durable, with a specific gravity of about 0.9 it is utilized for rollers, sills, posts, and to some extent in carpentry.

Cook and Collins (*6, pp. 74–75*) give the following description of the wood of the bay-rum tree:

A [myrtaceous] tree 45 to 50 feet (14 to 16 meters) high, the straight, rather long trunk 15 to 24 (35 to 55 centimeters) inches in diameter. Furnishes a moderately hard and heavy wood, fine and compact in texture. The sapwood is very light red with darker lines, while the heart is brownish red, brown, or, on account of its knots, almost black. It is susceptible of a very high polish. Specific gravity, 0.909. It is one of the best and most valued woods of these countries, very strong and durable, suitable for carpenters and cabinetwork and it is exported to some extent. The bark is rough and ash colored, and peels after the manner of the sycamore.

Within some bay sections in the West Indies there is a tree (*Pimenta citrifolia* (*Amomis carophyllata grisea*) closely resembling the bay-rum tree which is considered highly undesirable because of the poor quality of the oil which has the odor of lemon or anise. Seedling trees of this undesirable species may sometimes occur in bay plantations. They should be removed in order to avoid contaminating, adulterating, and lowering the quality of the bay oil during the harvesting and distillation process. In Puerto Rico and other Spanish-speaking countries this tree is known as "lemoncillo," "cinnamon bush," or "false" bay-rum tree.

Experienced growers can often differentiate between the desirable bay-rum tree and the undesirable lemoncillo tree, chiefly on the basis of the odor of the oil, but in marginal cases the nose is not sufficiently sensitive to detect it. The lemoncillo trees frequently have very small curled leaves and the general growth is less vigorous than the commercial bay tree, although these characteristics do not always hold. Hendricksen (*8, p. 74*) devised a colorimetric method for differentiating between leaves of the lemoncillo and bay-rum tree. His comments and description of the method are as follows:

Those who grow bay trees [(*Pimenta racemosa* (Mill.)) Moore] and sell the leaves to distilleries are well aware that the lemon-scented leaves are not alone valueless, but even objectionable, when mixed with those of the desirable variety. The identification of trees bearing lemon-scented leaves is not difficult provided the odor of lemon is so well developed as to be readily recognizable by the sense of smell. But with the lemon odor only slightly developed it is difficult to take proper precautions. Botanical differences such as shape and size of leaves and general appearance of the tree, may occasionally be useful indications but they are far from being reliable. The difficulty may be overcome readily by the use of a chemical test that is simple, reliable and applicable for use in the field.

Apparatus and reagent required for the test.—A porcelain mortar with pestle, a dozen test tubes with a capacity of about 35 cc., and a small measuring cylinder or a 5 cc. pipette. The reagent can be made by any druggist as follows: Dissolve 0.2 gram fuchsin in 100 cc. hot water. Let the solution cool and then add to it 2 grams sodium bisulphite followed by 2 cc. hydrochloric acid. Let the solution stand until the red color has disappeared, then add 100 cc. water and it is ready for use. Keep it in a well stoppered bottle and in a refrigerator if possible. If kept cool it will be serviceable for two weeks or more, but when kept at air temperature, and especially if the bottle is un-stoppered frequently, a fresh solution should be made daily.

Method.—Take a small table with the apparatus and reagent into the field. Pick from a bay tree two fully matured leaves of average size, cut them with a sharp knife and pestle the cut material in a mortar with a few drops of water.

When the material is partly disintegrated add 5 cc. of the fuchsin solution and continue pestling for about 1 minute. Wash the material into a test tube, rinse the mortar with water and mix the content. The solution usually becomes fully colored in a few minutes, but if the color is a muddy brown it must be left until it attains the full color which may take 10 minutes or more. The depth or the amount of color is not material; it is the tint that must be noted.

If the color of the solution is bright red without a tinge of violet, the leaves are desirable, being free from lemon-scented oil and the tree can therefore be marked accordingly.

If the color of the solution is a deep violet the leaves are so heavily lemon-scented as to be entirely unfit for the making of bay oil and the tree should be marked accordingly, or preferably it should be cut down.

If the color is but slightly violet tinted the leaves are undesirable. But since small variations can be distinguished only by comparison the following method may be applied. Pestle together samples of pure leaves with varying amounts of lemon-scented leaves, say 1, 2, 5, and 10 percent, and treat as previously directed. Retain these samples in test tubes as well as a sample of pure leaves without admixture of lemon-scented leaves. They may be used as standards for comparison for some time since the colors do not fade readily. A person having a keen eye for color may distinguish a difference between a preparation from a pure leaf and that from an admixture containing 1 percent or less of a heavily lemon-scented leaf. By leaving the solution until the suspended matter has settled smaller differences may be detected.

ESTABLISHING A BAY-TREE GROVE

Climate.—Bay trees are one of the few crops in Puerto Rico that will succeed under relatively low rainfall of 30 to 50 inches annually. The most productive and largest plantings, however, are located in medium to heavy rainfall areas of 70 to 100 inches. Near Cabo Rojo under rainfall conditions of 40 to 50 inches, bay trees grow slowly but satisfactory (fig. 4, *B*). Also, the bay groves in the Virgin Islands are largely located in regions receiving an annual rainfall of between 35 to 55 inches (*15, p. 30a*). At Mayaguez, bay trees thrive under an annual rainfall of about 82 inches falling chiefly during the months of April to October, inclusive. Low rainfall of 1 to 2 inches per month, or less, may occur between December to March, inclusive, during which time drought has resulted in death of young seedlings, but the total loss has not exceeded 5 percent.

The insular climates found in the Caribbean area are apparently ideally suited to bay culture inasmuch as the industry, for this or other reasons, has shown little spread to other areas during the past 100 years. The mean temperature in Puerto Rico varies between a high of 79.9° F. at Guayama (sea level) to a low of about 72° at Maricao and Aibonito (about 2,000 feet). In general, the temperature is about 5° warmer at sea level than at an altitude of 1,500 feet, above which few bay-rum trees are found. At Mayaguez the average annual temperature in January, the coolest month, is about 74.5°. During the warmest month of August the average temperature rarely exceeds 95°, or drops lower than 58°. There is an abundance of sunshine almost every day throughout the bay-growing districts.

Soil.—Bay-rum trees are found growing for the most part on relatively heavy clay on hilly and rolling land. A rooting depth of 3 feet or more appears desirable. Hillsides with heavy outcroppings of rocks and a thin covering of soil which is low in fertility are undesirable for bay trees (fig. 3, *C*). Soils in bay plantations in Puerto Rico vary in reaction from very acid (pH 4.5) to almost neutral. It is not known if the crop will succeed well on alkaline soil.

FIGURE 4.—(*A*) Seed from this tree are used for propagation purposes near Guayama; the lower spreading growth habit is particularly desirable for economical management. (*B*) Bay tree in a relatively dry region near Cabo Rojo producing 2.7 percent bay oil, the highest analysis recorded in Puerto Rico.

Bay-rum trees are usually planted on land which is too steep for the cultivation or growing of other economic crops. The slope may reach 60 percent or more. In the drier region near Cabo Rojo, however, many bay trees are found growing on moderately rolling land. In the pasture areas of this region it may be desirable to use closely planted bay trees around the borders of the pasture (see fig. 5, *A*) to serve not only as fence posts but also as shade for the livestock. A thin border of the wild and thorny pineapple (*Bromelia pinguin* L.), frequently used on field boundaries near Cabo Rojo, also can be used to further reinforce the fence near the ground.

Bay-rum trees usually produce better at the base of the slope than at the top. Also, the size of the trees and general vigor is usually better in the concave than in the convex areas of the slope. This is probably due to more fertile soil and better moisture conditions in the concave areas.

Propagation by seed.—Plantings in the U. S. Virgin Islands and to some extent those in Puerto Rico are sometimes established by cutting away the forest trees and underbrush and allowing the voluntary bay seedlings to gradually take over (fig. 6, *B*). After a year or two these seedlings are thinned to a distance of about 6 by 9 feet.

Most bay groves in Puerto Rico are planted systematically from propagated seedlings. The seed are usually collected in August when the drupes are hard ripe. The drupes are opened and the seed washed and planted *immediately* in flats or specially prepared seedbeds similar to those used for growing vegetable seedlings. These beds are

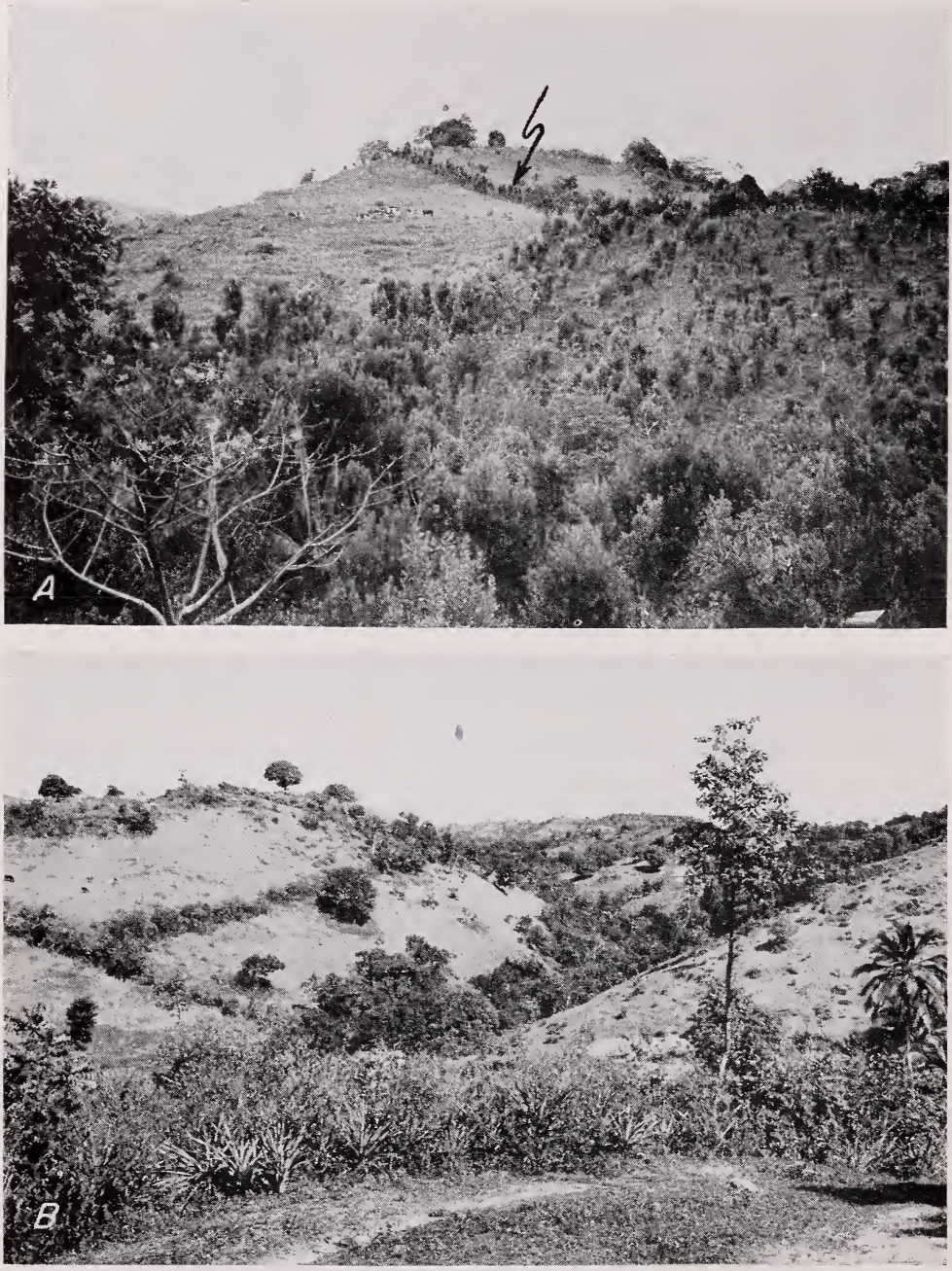

FIGURE 5.—(*A*) Bay grove in foreground and pasture above showing use of bay trees along fence row (arrow). Note more vigorous trees at base of hill. (*B*) Bay trees grow slowly but satisfactorily in the relatively dry rolling country near Cabo Rojo (see also fig. 4, *B*). A number of bay trees are mixed among the trees in this landscape.

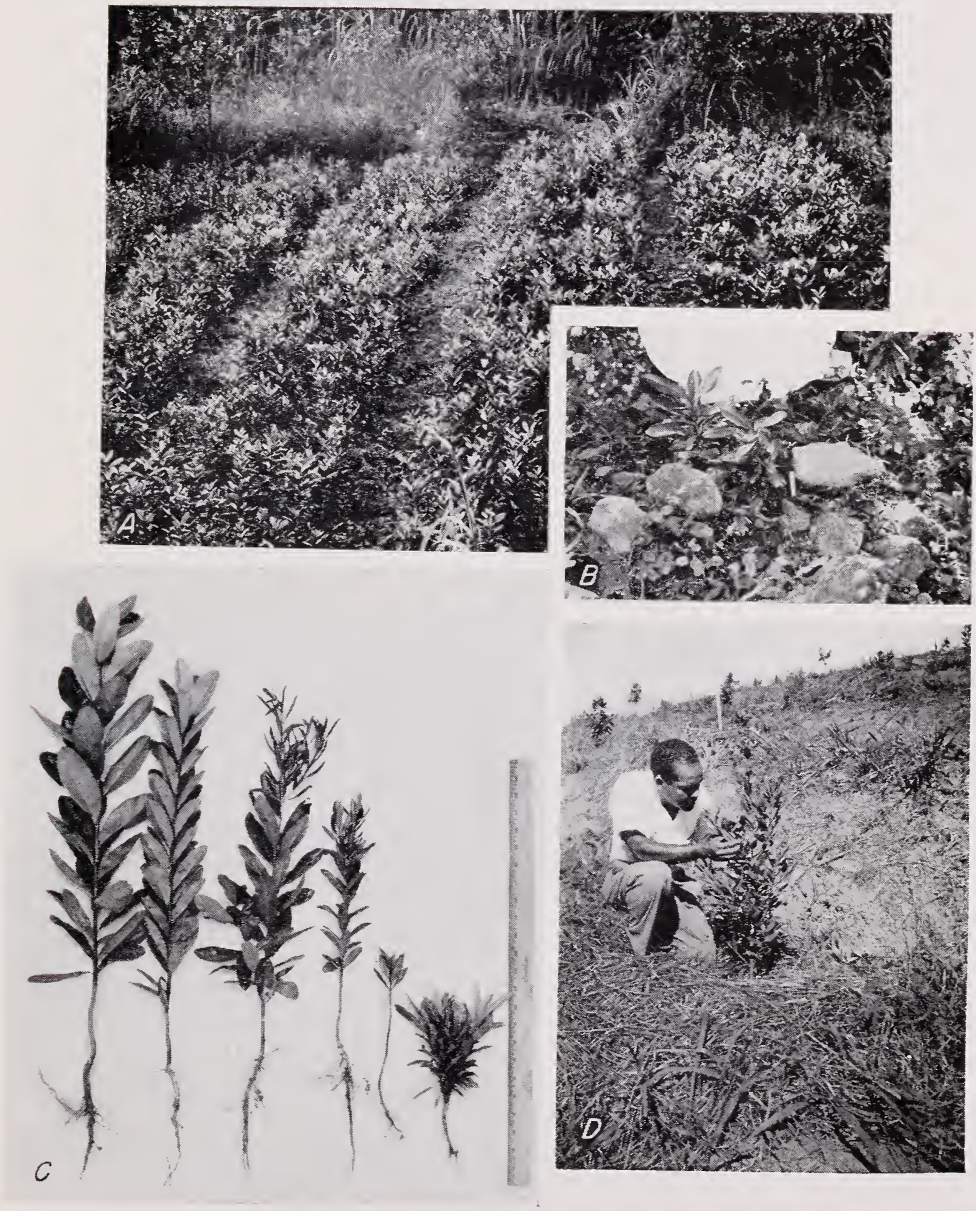

FIGURE 6.—(*A*) A nursery of bay seedlings near Adjuntas about 2-years old and ready for transplanting. (*B*) Two voluntary bay seedlings growing in proximity to established bay trees near Cabo Rojo. (*C*) Bay seedlings vary widely in character and vigor of growth. The two seedlings on the left are satisfactory for transplanting; the others are runts and will be discarded. (*D*) A mulched bay seedling growing on an individual terrace at the Federal Experiment Station.

raised about 6 to 8 inches, 3 to 4 feet wide, and of a convenient length. A mixture of rich soil, rotted manure, sand, and leafmold in about equal parts makes an excellent seedbed mixture. Manure is the most important ingredient and should be used freely if available. The seed are planted in rows about 6 to 8 inches apart and sown ¼ to ½ inch deep at the rate of about 10 seed per linear foot. The seedbed should be located in partial, but not heavy, shade, and irrigated during dry periods. Germination of 50 percent or more is reported by growers; as high as 98 percent germination has been obtained under laboratory conditions at Mayaguez (see fig. 2, *C*).

When the seedlings are about 3 to 5 inches high they are transplanted to nurserybeds or to 1- or 2-quart cans. The beds are 3 to 4 feet wide, any convenient length, and with aisles about 2 feet wide between beds. The beds shown in figure 6, *A* are located with a northern exposure along a creek bank where it is moist and cool. The seedlings are grown for approximately 1 year in these nurserybeds when the tap roots are severed about 6 inches below ground in order to induce a more fibrous root system. The seedlings are usually ready to transplant to the field after 1½ to 2 years in the nursery. The seedlings vary widely in type and vigor (fig. 6, *C*); only the sturdy plants should be used.

No nurseries in Puerto Rico handle bay seedlings. Some growers occasionally have trees in excess of their planting needs which are offered for sale. The usual practice is to dig these seedlings from the nurserybeds with part of the soil attached to the root system at the beginning of and during the rainy season. The trees are placed in quart tin cans and additional rich soil is packed moderately around the roots. The potted trees are shaded and watered frequently until trucked to their destination.

The Federal Experiment Station conducted a survey in 1945 with the object of locating bay-rum trees yielding a high percentage of oil. The highest yielding specimen discovered was one near Cabo Rojo, which bore leaves with 2.7 percent bay oil. The grafting of superior clones on seedling bay-rum trees never has been practiced commercially in Puerto Rico. A number of whip grafts were made on small stocks of 5-year seedlings on the Las Mesas station property near Mayaguez. The average "take" was less than 50 percent for grafts made from the base, mid-, and tip parts of the shoots. Grafts made with shoot tip scions only showed 100 percent take. More research is needed in grafting to obtain groves of uniform trees yielding high oil content.

Planting.—Bay seedlings should be transplanted to the field at the beginning of or during the rainy season. Planting distances vary; a common distance is 5 to 6 feet between trees in rows, with the rows spaced 8 to 10 feet apart. Since bay-rum tree plantings are left in sod with no cultivation it is not necessary that the rows be planted in a particular row arrangement; however, the Soil Conservation Service is recommending contour planting of rows where feasible. This facilitates construction of a contour lane or road at intervals for harvesting and removal of leaves from the planting. Also, if the slope is moderately steep, contour paths can be cut or plowed out midway between the rows to facilitate traffic in harvesting.

The homemade instrument shown in figure 7 is useful in laying out contour lines. Length of the instrument is the same as the desired planting distance between the trees in the row, or e. g., 5 to 6 feet. Three-foot stakes of bamboo or native trees can be used to mark the location for each tree.

The trees should be dug from the nursery after a rain and shortly before or, preferably, on the day they are planted. The roots can be surrounded with moist peat moss, sawdust, or similar organic debris, and wrapped in burlap in order to prevent the roots from drying during the transplanting process. If the roots are allowed to lie in the sun and dry, the percentage of survival and vigor of the trees will be greatly reduced the first year after planting. Survival and early

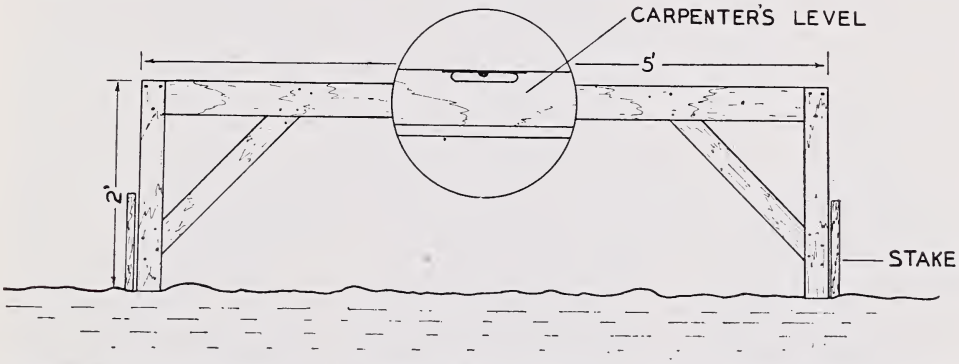

FIGURE 7.—A home-made level useful for locating terraces on sloping land at the same level on a contour line, or for establishing a contour line only. As an example, the right stake above is near the border of the new bay plantation and indicates the center of a terrace. The level is placed as shown. By holding its right leg stationary the left leg is raised or lowered up or down the slope until the water bubble indicates that equipment is level; the left stake is then driven as shown. The leveling equipment is then moved to the left on a contour level line around the slope as terrace stakes are driven a specified distance apart. Length of bar may be 5 feet, or more, depending upon planting distance in the row.

growth is usually better if a handful or more of soil is left attached to the root system.

Planting is facilitated by first clearing the area and leaving the hay and debris for later use as mulch around the young trees. A garden shovel or ditching spade is useful for digging the holes which should be large enough to comfortably accommodate the root system. Trees are planted at the same depth they grew in the nursery. Top soil should be packed well around the roots in order to avoid large air spaces in the soil which allows soil to dry too rapidly. After planting, about one-third of the top of the seedling is removed with a machete or pruning shears, in order to reduce the top in proportion to the roots. Although no data are available on fertilization of bay trees at planting, it is suggested that a shovelful of rotted manure, when available, be placed in the planting hole to stimulate early vigorous growth. An alternative is to use about a handful of ammonium sulfate or a 10–10–5 commercial mixture in a ring on the surface of the soil about 6 inches from the base of the seedlings; a covered trench should be used on sloping land. Chemical fertilizers should preferably be applied about

1 to 2 months after planting when the seedlings are in better condition to utilize them.

For coffee, the Soil Conservation Service suggests the use of individual terraces about 2 to 3 feet in diameter and slightly tilted inward to collect moisture and to conserve soil. It may be worth while to consider such a practice for the bay-rum tree, although no data are available for bay trees at this time. The tree shown in figure 6, *D* has been prepared in accordance with this recommendation.

TRAINING THE BAY TREE

Although the bay-rum tree will attain a height of 60 feet or more if allowed to develop normally (fig. 3, *B*), the commercial tree is usually not permitted to reach a height of more than 10 to 15 feet (fig. 3, *A*) to facilitate management. The pruning is performed at harvest when the leaves and limbs are removed. The tree shown in figure 3, *A* is considered of desirable commercial size and shape. One or two central leader trunks with many side branches are more convenient to harvest than a bushy tree with many spindly trunks. While the young tree is developing, a vigorous leader should be selected and encouraged (fig. 8) and any smaller competing leaders should be either removed or subdued by heavily cutting back to a strong lateral limb to give the tree a spreading habit.

Bay trees will live for many years in spite of rather heavy and regular pruning at harvest. When old trees become poorly shaped, gnarled, and low in vigor (fig. 9, *B*) it may be desirable to encourage a young leader from the base of the tree to gradually take over, after which the old section of the tree is removed entirely.

SOIL MANAGEMENT

Cover crops.—Voluntary weeds and grass comprise the only cover crop used in bay plantings in Puerto Rico and the U. S. Virgin Islands. This cover is cut once or twice a year with a "machete," and particularly preceding the harvest period in order to facilitate traffic in the grove. The possibility of growing a permanent legume cover should be given further study. Legumes are known to furnish nitrogen to crops growing in combination with them. Legumes showing promise in Puerto Rico are tropical kudzu (*14*), trailing indigo, *Indigofera endecaphylla*, and *Crotalaria spectabilis*.

Fertilization.—Experimental results are not available to show the advantages of the use of commercial fertilizers in bay groves. A grower near Ponce used 1 pound of ammonium sulfate per tree on several hundred 10-year trees and noted a very definite response in shoot and leaf growth. Many new shoots appeared close to the ground and the yellowish and reddish color at the tips of the shoots disappeared. Fertilized trees had an over-all darker green color and the oil content of the leaves was relatively higher (see table 3). Another grower near Adjuntas used ¾ pound per tree of a 10–6–16 fertilizer in April and doubled the total leaf production the following year without noticeably affecting the oil content of the leaves. There was, however, no check plot to prove that the increased leaf production was due entirely to fertilizer and not in part to weather conditions or other factors.

FIGURE 8.—A moderately vigorous and well-trained 2-year bay tree near Ponce.

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FIGURE 9.—(*A*) Young bay planting near Adjuntas where leaves are stripped from the trees, picked up from the ground or a canvas catcher, and sacked. (*B*) An old bay planting near Humacao, where shoots and branches are pruned off at about 14-month intervals. (*C*) 15-year bay trees near Adjuntas where leaf stripping is practiced. (*D*) New shoot growth at the top of a 10-year bay tree near Ponce approximately 1 year after harvest.

Nitrogen is the element most frequently lacking in Puerto Rican soils. Phosphorus is also important, particularly in the hill sections. Benefits from applications of potassium have not been so clearly demonstrated. Thus, it appears that nitrogen is the element which should give the most response per unit weight of fertilizer and should be given first consideration in fertilization of the bay plantation. Inasmuch as soils vary considerably over the island, however, it would probably be wise procedure for the grower to use small plots in his bay grove and test separately and in combination the following fertilizers: Ammonium sulfate (200 to 400 pounds per acre), muriate of potash (KCl—75 to 150 pounds), and phosphoric acid (P_2O_5—200 to 400 pounds). This procedure should provide some idea of which fertilizer to use and the approximate amount required to give the most economical and optimum oil production per acre.

Mulching.—Most of the bay prunings and a large quantity of the spent leaves are used in the boiler furnace to produce steam for distillation of the bay oil. However, some distilleries have large quantities of spent leaves and ashes left over during and after the distillation season (fig. 10, *D*). A grower near Guayama hauls these leaves to the grove and distributes them beneath the trees to a depth of 4 to 6 inches, which is a wise practice. Grass cut between the trees should be

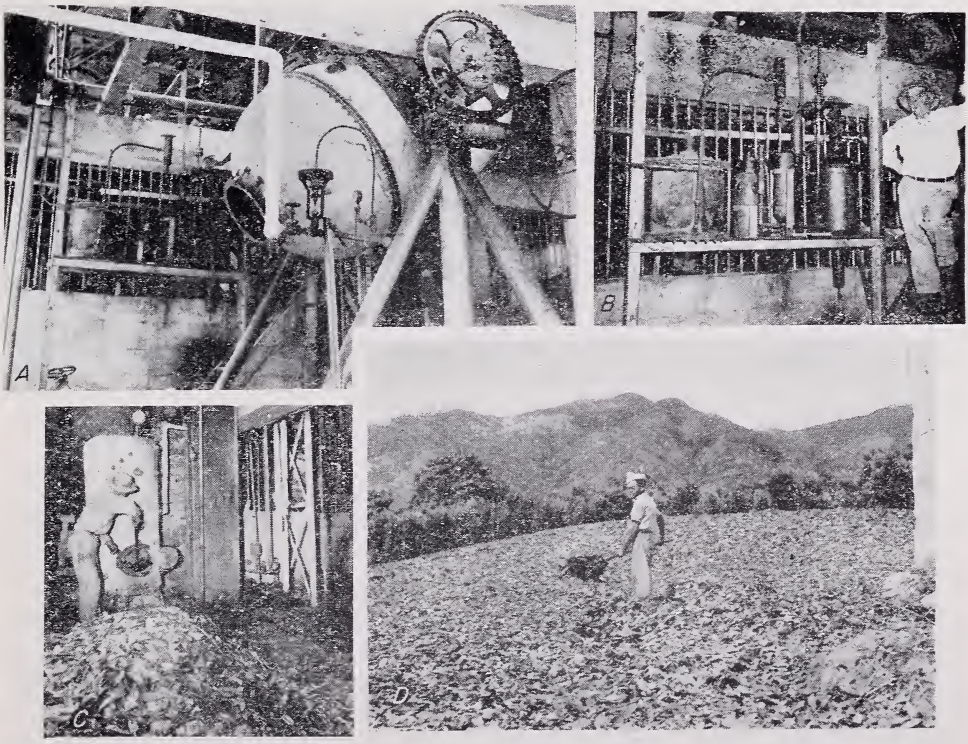

FIGURE 10.—(*A*) Vat and accessories for distilling bay oil near Ponce, P. R. Vat is in discharging position; for filling, it is turned upright and bay leaves are run through a silage cutter directly into the vat. (*B*) Bay oil fractionating and collecting equipment (see at left of vat in *A*). (*C*) Furnace and steam boiler located outside and to the left of the distilling vat in *A*; prunings and spent bay leaves are used for fuel. (*D*) Pile of spent bay leaves at a distillery near Guayama. Leaves not utilized for fuel are hauled to the bay grove and scattered as mulch beneath bay trees.

gathered and also placed about the base of the trees, forming a ring of mulch about 2 feet wide and 6 to 12 inches deep. Mulching has several advantages: It conserves moisture, reduces the temperature of the soil about the roots, provides organic matter to the soil, and supplies nutrients to the tree roots.

INSECTS AND DISEASES

Bay trees have relatively few insects and diseases. The only insect causing moderate damage to the leaves is the sugarcane weevil (*Diaprepes abbreviatus*, L.), commonly called "vaquita" in Puerto Rico. This large snout weevil feeds mainly upon the margins of the leaves, removing large irregular or half-moon areas (fig. 2, *A*). Relatively more weevil damage is experienced when the bay planting is located near sugarcane. The weevil is also a pest in citrus groves and avocado orchards where some growers permit guinea fowls to forage and consume large numbers of the weevils as they emerge from the ground. A 3-percent DDT dust has been found useful in reducing these insects on young avocado trees. It is probable, however, that commercial dusting of bay groves with DDT would not be economical inasmuch as the insect damage is usually localized and moderate. Damage to newly planted seedlings, however, may necessitate such treatment to speed early vegetative development.

No specific disease organisms have been identified in bay plantations insofar as the literature shows. Young bay seedlings in the station plantations have been noted to suddenly die after a period of several months of growth following transplanting. The leaves become light green to yellowish, then turn brown and adhere to the tree. Death of the tree appears to be caused by a root rot or drought, since it frequently occurs during the dry season. Also, some dead trees have exhibited bark-feeding damage to the roots by an unknown pest.

In a hillside section of a bay plantation near Adjuntas several trees were noted to be dying as shown in figure 3, *C*. The grower attributed this difficulty to an unknown root disease, although the thin infertile soil conditions in these areas may have been an important contributing factor.

HARVESTING

Season.—The principal harvesting season in Puerto Rico is from January to June, but some harvesting is performed throughout the year near Guayama. It is claimed by the growers that the bay-oil content in leaves is higher during the relatively dry season from January to June than during the rainy season. Preliminary results obtained by Hendricksen (*9, p. 21*) showed that a charge of 550 pounds of mature bay leaves yielded 2,270 cc. of oil whereas a similar charge of immature leaves yielded 1950 cc. Growers are of the opinion that leaves coming from trees in high altitudes contain relatively less oil than those grown near sea level. Sufficient experimental data are not available at this time, however, to fully substantiate these results and observations.

A survey conducted by this station of the oil content of 120 bay-leaf samples from different regions in Puerto Rico and St. John, United States Virgin Islands, indicated that rainfall is an important factor

influencing the growth of bay trees and the production of bay oil. The oil content seemed to vary inversely with the amount of rainfall. It will be noted in table 3 that the bay-leaf samples from Ponce showed 2.1 percent oil which was as high as that obtained near Cabo Rojo where annual rainfall is about 30 inches less. Previously bay samples obtained from the same Ponce trees showed 1.7 percent. It should be pointed out, however, that 2 months before the last sample was taken the grower near Ponce applied 1 pound of ammonium sulfate to each tree and this may partly account for the 0.4 percent rise in oil content. The highest percentage of oil was obtained from leaves coming from St. John, where the annual rainfall is between 30 and 45 inches.

From the data in table 3 it will be noted that the percentage of oil ranged from 1.03 to 2.76 in Puerto Rico, whereas the oil content from bay-leaf samples from the United States Virgin Islands ranged from 1.32 to 3.40. The average precentage of oil content for the 120 leaf samples was 2.02 percent.

TABLE 3.—*Oil content of bay leaves from different localities in Puerto Rico and from St. John, United States Virgin Islands*

Municipality	Samples	Oil content of leaves		Annual rainfall [1]
		Range	Mean	
	Number	*Percent*	*Percent*	*Inches*
Adjuntas	19	1. 03–1. 84	1. 6	88. 4
Mayaguez	17	1. 11–2. 12	1. 6	81. 4
Mayaguez	12	1. 36–2. 16	1. 7	81. 4
Ponce	14	1. 19–2. 22	1. 7	65. 9
Ponce [2]	12	1. 36–2. 56	2. 1	65. 9
Guayama	16	1. 80–2. 19	1. 9	65. 0
Guayama	12	1. 44–2. 48	1. 94	65. 0
Cabo Rojo	8	1. 40–2. 76	2. 1	49. 0
St. John, V. I.[3]	10	1. 32–3. 40	2. 4	44. 7

[1] Estimated from data obtained at nearest station.

[2] Trees from which these samples were taken had been fertilized 2 months before picking.

[3] Samples from St. John had lost about 15 percent moisture in transit and the figures were so corrected. Fresh leaves usually average around 65 percent moisture in Puerto Rico.

While high percentage of oil in the leaves is desirable, the factor of most interest to growers is high production of oil per acre over a period of several years. A tree having a high percentage of oil may not necessarily produce well on an acre basis and over a period of years. In a dry region, such as near Cabo Rojo, growth is probably slower and the interval between harvests is somewhat longer which may account for the higher percentage of oil. It has not been established, however, whether the net profit is higher in dry regions where oil content is relatively higher and harvesting less frequent than in moist regions where oil content is lower and harvesting is practiced more often.

The peak periods of harvest will vary depending upon the urgency of duties with other crops and upon the rate of leaf development which is affected by many factors such as soil type, fertility, moisture, and cultural care. Intervals between harvest may extend from 9 months to 2 years but if the leaves are left longer than 2 years they tend to drop, especially during the dry season. During years of high prices, the leaves may be harvested at intervals of around 12 months. Fourteen to 18 months, however, is considered about an average harvest interval in normal times in Puerto Rico.

Harvesting methods.—Two methods of harvesting are employed. In one method leaves are stripped from the trees with few limbs or shoots being removed except those at the top, which are pruned to keep the tree low (fig. 9, *A* and *C*). In the other method both shoots and leaves are removed (fig. 11, *B*) and tied in bundles for transportation to the distillery (fig. 11, *C*), or, the shoots and limbs may be tossed into a pile where women, paid on a lower hourly basis, pull the leaves and place them in burlap bags which are carried by animals down the steep slopes (fig. 11, *A* and *B*). In recent years a jeep with a trailer has proved economical and rapid for transporting bay leaves, provided

FIGURE 11.—Several methods are used for transporting bay leaves to the distillery. (*A*) This grower near Ponce has pruned off the shoots and branches and moved them to the shade where women pull and bag leaves. (*B*) Sacks of bay leaves are often tied to a donkey or loaded on jeeps with trailers for transportation down steep slopes. (*C*) In a plantation near Guayama branches are tied in bundles and stored in a barn (see rear) before macerating through silage cutter.

the slopes are not too steep. The "deshooting" method is used both near Ponce and in the Guayama region, whereas the method of removing mostly leaves and but few limbs is used near Adjuntas. The deshooting method is simple, more convenient, and requires less labor. Also, it tends to keep the tree within bounds and the center of the tree free from barren twigs. However, this heavy removal of limbs, shoots, and leaves may lengthen the harvest intervals and tend to reduce yield per tree. It has not been experimentally established which of these methods is the most profitable from the standpoint of oil produced over a period of years.

The harvesting crew may consist of a dozen men who are paid either by the day or by the hundredweight of leaves harvested. The men may then be subdivided into groups of three men, organized with two men cutting the limbs and the other making the bundles. Where the harvesters are paid by the 100 pounds, the average man can harvest between 700 and 800 pounds a day, some men harvest as high as 1,500 pounds. Men paid by the hundredweight require less supervision, and there is frequently a desire on their part to work faster in order to obtain a higher daily income. Inasmuch as the harvesting can be spread over several months, there is no need for hiring large numbers of men to do the job in a relatively short time; the job can be spread over a period of 6 months or more if necessary. Also, the still can accommodate only a certain quantity of leaves and it is not good practice to accumulate large quantities of bay leaves awaiting distillation.

In the region of Guayama where there is one large bay distiller and the groves or clumps of bay trees are scattered over a rather large area, the bay distiller hires one or two reliable men on a salary basis who contact the various farmers having bay leaves for sale. A price is agreed upon by buyer and seller on the basis of 100-pound bundles of leaves, including shoots and stems. The grower may harvest his own bay leaves, or the bay distiller may furnish the men who perform the harvesting and pay a base rate to the owner of the property for the leaves obtained. The bay distiller also supplies a truck that tours the regions where harvesting is in progress, collects the bundles, and makes cash payments to the growers.

Yields.—From 10,000 to 30,000 pounds of fresh bay leaves may be obtained per acre. Puerto Rican growers in general report around 15,000 pounds per acre. As stated previously, however, yields may vary considerably with frequency of harvest, rainfall, and soil fertility.

PROCESSING

Storing leaves.—Bay leaves may be processed immediately upon arrival at the distillery or they may be stored for a short period after harvest (not more than a month, preferably less (*4*, *p. 48*) in a well-aerated bin as shown in figure 11, *C*. Storage for about three days in such bins is thought by the growers to increase the yield of oil and facilitate the handling of the leaves. Also, more leaves can be packed into the distilling vat, thus making it possible to obtain more oil per distillation.

The leaves are first crushed and macerated by passing them through a chopper of the types shown in figure 12. The chopper should be conveniently located above the distilling vat so that the crushed leaves

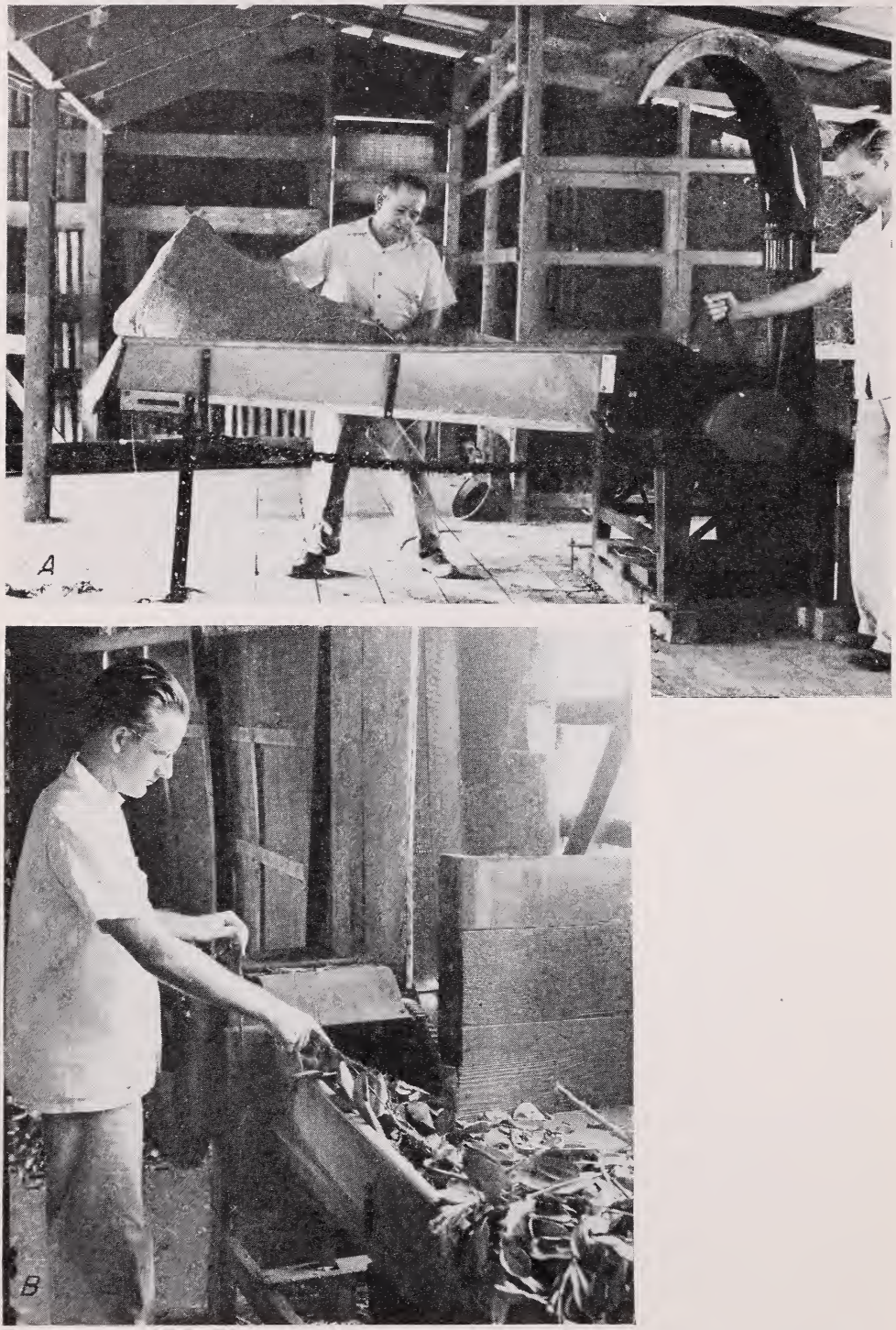

FIGURE 12.—Two types of electric motor-driven silage cutters, used for macerating bay leaves and separating them from the branches.

fall down the shoot directly into the vat where they are packed moderately. This arrangement is shown in figure 10.

Distillation.—Only a simple form of apparatus is required for the distillation of essential oils from such materials as bay leaves. All that is necessary is to provide a means of passing a current of steam through the bay leaves to be distilled, and have them confined in a chamber and arranged so that the steam may then pass out and into a suitable condenser provided with a receiver.

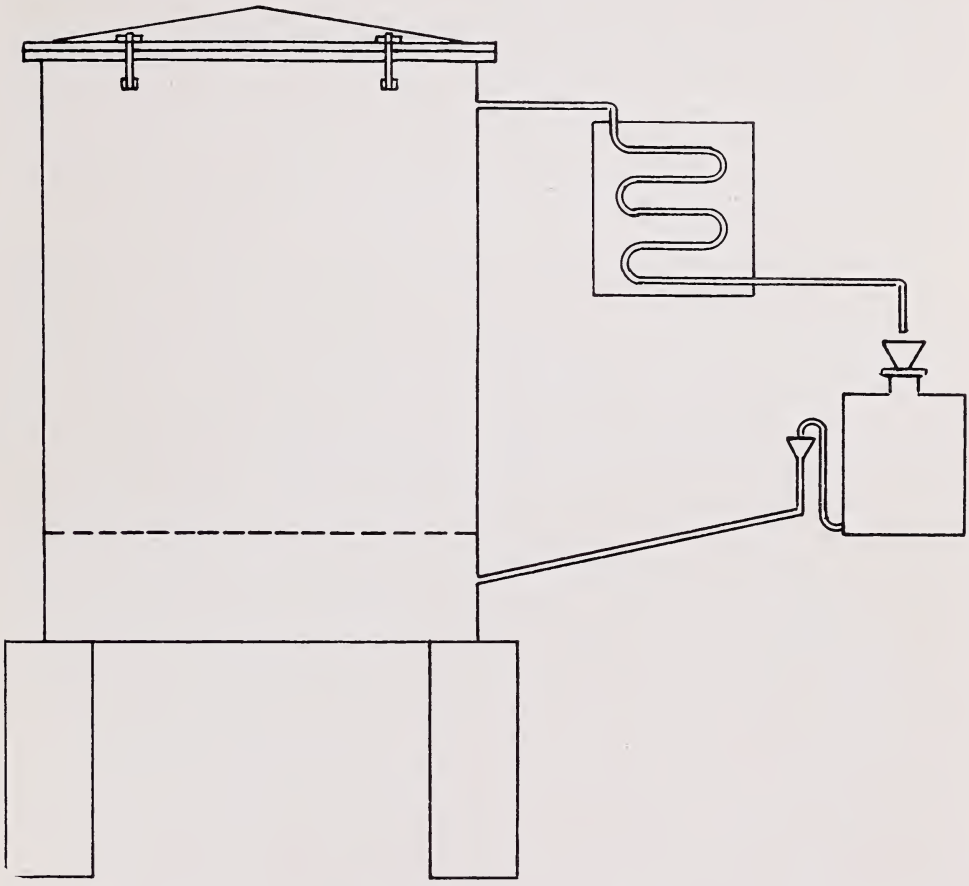

FIGURE 13.—Diagrammatic sketch of simple still for steam distilling oil from bay leaves. Main disadvantage of this arrangement is the inconvenience in discharging the contents after distillation. This can be overcome by generating steam in a separate boiler (see fig. 10).

A still of simple design is shown in figure 13. A large cylindrical iron or copper drum about 4½ feet by 2½ feet has a perforated grating attached to the sides about 10 inches from the bottom; a lid fits upon a flange at the top and is so arranged that it can be made steam tight by a suitable packing material upon which the lid is bolted with winged tip nuts. The drum is mounted over a small furnace or fire pot. Near the top side of the drum a pipe is provided for carrying the steam and products of distillation to the condenser, which is a simple spiral tube around which a current of cold water circulates.

Salted fresh water or sea water [3] (one-third sea water to two-thirds

[3] Sea water contains about 5 percent salt (sodium chloride).

fresh water) is placed in the bottom of the drum below the grating, the bay leaves are packed into the vat, the lid is tightly closed, and the distillation conducted by placing a fire beneath the drum. In experiments performed at the Federal Experiment Station in Puerto Rico Arrillaga and Jones (*3*) have shown that distillation from salt solution (25 percent sodium chloride) gave a higher yield of oil and higher phenol content than the distillation without salt.

By placing the condenser at a sufficient elevation, and by using the well-known Florentine-form flask for effecting the separation of the oil from the water, it is easy to arrange the apparatus so that the condensed water may return directly to the still as shown in the diagram. This arrangement has several advantages; it reduces the amount of water necessary, it obviates the danger of the still being injured caused by all the water being boiled away with the consequent burning of the still, and it has the additional advantage of returning any oil to the still which may escape with the waste water, thus permitting its recovery by redistillation.

One of the main disadvantages of this type of still is that it is inconvenient to discharge the spent leaves when the distillation is finished. Ths difficulty may be overcome by generating the steam in a separate boiler (fig. 10, *A* and *C*) so that the drum containing the leaves can be opened both at top and bottom, thus permitting it to be charged from the top and discharged from the bottom, or similar operations can be carried out by placing the still on a pivot as shown in figure 10, *A*. When an outside source of steam is used, as in this type of still, there is no return flow of the distillate water to the still. Distillation of one batch usually lasts 9 hours and can be shortened considerably by higher steam pressure or in the case of direct fire distillation by the use of salt water beneath the grating. Previous maceration of the leaf material also shortens distillation time.

In the distillation process the oil comes over in two fractions which are usually collected separately. In the first fraction, the oil is lighter than water with a phenol content of about 50 percent and higher. In the second fraction which is smaller, the oil is heavier than water consisting almost exclusively of phenols. By mixing the two fractions an average phenol content of 60 percent and even higher is obtained. Variations in the proportions of these two fractions are attributable at least in part to the relative freshness of the leaves and the season in which they are collected. These proportions in turn influence the phenol content and specific gravity of the complete final oil. The yield of final oil obtained in the process ranges from 0.75 to 1.25 percent; the latter percentage is considered about normal.

CHEMISTRY OF BAY OIL

Oil of bay is a yellow or brownish-yellow liquid with a pleasant aromatic odor and a pungent spicy taste. On exposure to air the oil becomes brown. The chemistry of bay oil was first investigated by Markoe (*10*, *p. 438*) who identified eugenol as one of its components, and later by Mittman (*11*, *p. 529*) who in addition to eugenol found methyleugenol. A more complete investigation was carried out by Power and Kleber (*13*, *p. 60*) who identified for the first time an olefinic terpene which they named myrcene. In addition to myrcene,

they also established the presence of *l*-phellandrene, citral, chavicol, and methylchavicol.

According to Gildemeister and Hoffman (*7, p. 194*) oil of bay contains the following constituents, listed in order of amounts present, eugenol, myrcene, chavicol, methyleugenol, methylchavicol, phellandrene, and citral. Of these, by far the most important are eugenol and myrcene.

Eugenol is a phenyl, namely 4-allylguiacol. Its boiling point is 252–3° C. Its specific gravity is 1.0664 at $^{20}/_{4}$° C., and its refractive index at 19.40° C. is 1.5416. On oxidation it gives vanillin. In addition to its occurrence in bay oil, it is found in relatively large amounts in oil of cloves and clove stems; it is also found in oil of cinnamon leaves.

Myrcene is an open chain hydrocarbon, one of the so-called olefinic terpenes. Its boiling point is 167° C. Its specific gravity is 0.8023 at 15° C. and its refractive index is 1.4673. It is susceptible to change, and, on standing, polymerizes to a thick oil. Chavicol, the third most important constituent in bay oil, is present only in small quantities, as are the remaining constituents.

According to the National Formulary (*2, p. 348*), oil of bay shows the following constants: Specific gravity at 25° C., 0.950 to 0.990; it is laevorotatory, but the angle of optical rotation in a 100-mm. tube at 25° C. does not exceed −3°; refractive index at 20° 1.5070 to 1.5160; phenol content, not less than 50 percent and not higher than 65 percent by volume; solubility, clear or only slightly turbid with equal volumes of alcohol or glacial acetic acid.

Freshly distilled oil forms a clear solution with alcohol. Oil that has been kept for long periods of time will usually yield a somewhat turbid solution when mixed with alcohol. This is due to the decrease in solubility of the oil brought about by the action of light and air. Under these conditions the unstable hydrocarbon myrcene $C_{10}H_{16}$ is converted into the polymeric and very sparingly soluble diterpene $C_{20}H_{32}$.

The specific gravity of bay oil is generally in direct proportion to the phenol content of the oil. However, slight variation in the amount of methyleugenol or methylchavicol present may account for exceptions to this rule. Although the phenol content is usually taken as the criterion for the quality of bay oil, it is sometimes claimed that this is not a good criterion of quality. However, oil of bay is often employed in toilet waters because of its medicinal value which depends largely upon its phenol content and, for this reason, oil of bay with a high phenol content is considered superior.

The dark color of bay oil is sometimes caused by the presence of heavy metals, obtained by contact from iron stills. A considerably lighter oil can usually be obtained by preventing contact with the heavy metals.

Adulteration.—Carbon disulfide can be used to test for the presence of water in the oil. However, this test is so sharp that even traces of water, always present in distilled essential oils, causes turbidity in the solution. For this reason bay oil is rarely without a certain amount of water.

Alcohol and kerosene are the adulterants often used in bay oil in the West Indies. American or European dealers sometimes use clove stem oil or clove leaf oil. Other adulterants used are fractions ob-

tained from the manufacture of eugenol from oil of cloves or terpenes which are obtained as byproducts in the manufacture of terpeneless bay oil.

Terpeneless bay oil.—Terpeneless bay oil is made by removing the greater part of the terpenes from the regular bay oil, usually by fractional distillation. The removal of myrcene which so easily polymerizes in the regular oils makes these terpeneless oils not only more soluble but also prevents the oils from becoming insoluble with age. They are, therefore, very valuable for the manufacture of bay rum and toilet waters of similar type where good solubility is essential.

PREPARATION OF BAY RUM

Bay rum is prepared in two ways, (1) by distillation, and (2) by mixing bay oil with white rum or alcohol; the former is considered the best. It is prepared by the following method: White rum and bay leaves are placed in a still in the proportion of 1.3 pounds of rum to each pound of green leaves or each ½ pound of dry leaves and enough water is added to cover the leaves. The whole of the distillate is collected, which forms the genuine distilled bay rum of commerce. The second method of preparing bay rum is as follows: Mix 2 gallons of bay oil with about 100 gallons of rum. A little magnesium is added to aid blending.

There are about five bay oil distilleries in Puerto Rico. Each distiller has his own method of distilling, some working with direct live steam generated in a separate boiler, others with direct fire stills. The fuel consists of exhausted sun-dried bay leaves and wood alone or mixed with coconut husks or other materials. In general, the stills are rather primitive, one is quite modern. Their construction, the methods, and especially the length of distillation greatly influence the phenol content which in oils of best quality may be as high as 65 percent.

The altitude, soil, season, and weather conditions also are thought to influence phenol content of the oil. Even more important are freshness and age of the leaves which, as pointed out earlier, are often left on the tree for 13 or 14 months before being collected. A yearly harvest results in a somewhat lower phenol content but greater yearly yield of oil. According to local producers the finest oil is contained in the green stems of the leaves and flowers but these are rarely used for commercial production of bay oil. One bay oil distiller near Guayama, P. R., distills as high as 1,000 pounds of oil per week. His method of distillation consists of generating steam in a large boiler and passing it through two or three distillation chambers at the same time, each chamber containing 450 to 500 pounds of fresh leaves. With this system he is able to distill 4 to 6 batches of leaves per day. The oil is collected with the Florentine-flask system but instead of returning the distillation water to the still, it is transferred to a large settling tank where the heavy oils settle to the bottom and are drawn off a intervals. These heavy oils are high in phenol content and are used to fortify the higher fractions when their phenol content drops below 55 percent. With this system the distiller is in a position to offer a more uniform oil assaying between 55 and 60 percent phenol and consequently finds a ready market.

PACKAGING AND MARKETING

Bay oil is usually packed in 50-pound cans but it may be packaged in odd sizes, depending upon the cost and availability of different-sized containers. Two types of containers are shown in figure 14.

FIGURE 14.—Bay oil is packed for export shipment in tin cans. *A*, Kerosene-type can holding 5 gallons or 40 pounds of oil is more frequently used. *B*, The 6-pound cans in cartons are being used temporarily by a Guayama grower because they were available in quantity at a reasonable price.

There are several methods of marketing bay oil. About one-third to one-half of the oil produced in Puerto Rico is sold locally; the rest is usually sold through agents to buyers in the States. Bay oil can be held almost indefinitely without deterioration provided it is packaged airtight.

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POINTERS ON BAY-OIL PRODUCTION IN PUERTO RICO

1. The bay-oil industry is a small but old enterprise in Puerto Rico. Total acreage approaches 1,000 acres, most of which is located in the southeastern section. Annual bay-oil production in Puerto Rico is between 25,000 and 50,000 pounds; market price may vary from 0.80 to $2.50 per pound, but usually averages around $1.40.
2. Bay-rum trees are grown for the most part on the heavier slightly acid clay soils which may be rocky, relatively steep, and unsuited for most agricultural crops.
3. The seedling trees are germinated and grown in nurseries by special technique and transplanted to the field at distances of 5 to 6 feet apart in rows 9 feet apart. Harvesting of leaves can begin in 4 to 5 years after planting. Sod cut once or twice a year is the usual soil-management program; nitrogen fertilizer has shown definite response where used in commercial groves.
4. Bay trees will grow satisfactorily in regions of 35 to 50 inches of rainfall annually, but growth and production are better in regions receiving from 75 to 100 or more inches. Temperatures encountered from sea level to 1,500 feet appear to be most favorable, with apparently better growth from sea level to 500 feet.
5. Bay trees are trained to one or two main trunks with numerous side branches. Tree height is maintained at about 10 to 12 feet by heavy pruning of the top.
6. Two harvesting methods are used: (1) The leaves may be stripped from the limbs with little pruning of branches, or, (2) the small- and medium-sized branches may be removed with leaves intact, after which the leaves are either pulled and bagged in the field or the limbs are tied in bundles and transported to the shed.
7. Bay-rum trees have few insects and diseases, all of which are of minor importance.
8. Interval of harvest is from 12 to 18 months depending upon growing conditions, labor available, still capacity, and market conditions. Bay leaves may yield from 1 to 2 percent oil upon distillation, but occasional trees will assay as high as 2.76 to 3.40 percent. Yields of fresh bay leaves may vary from 10,000 to 30,000 pounds per acre, with an average of around 15,000 pounds.
9. Bay oil may be shipped direct to large consuming centers in tins weighing up to 50 pounds, or it may be made into bay rum and sold locally, or sent to distant markets.
10. The bay-oil industry might undergo some expansion but it should be accomplished by a strong technical research program in finding new uses for the oil and by an organized and effective advertising program for the products.

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